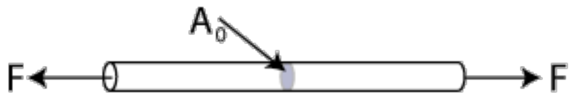
Sample: Mechanics Kinematics Dynamics - Stress and Strain

Mechanical stress.

Mechanical stress is used to explain process of deformation in objects. Force applied to object causes the internal distribution of forces. Mechanical stress is the internal distribution of forces. External forces seek to change structure of body, but stress prevents changes of structure of body. We can see that stress is an internal reaction of molecules and structure of material. All in all, deformation causes mechanical stress. We can submit stress as vector quantity, it's very simple and usefull for a lot of technical problems. If quantity has "magnitude" and "direction" it is called "vector" quantity.



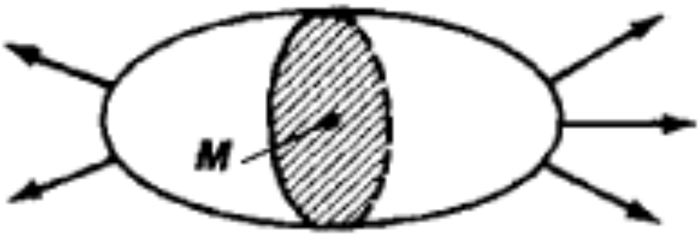
Intermolecular forces and collisions are explained cause of mechanical stress.
There is mathematic definition of mechanical stress:

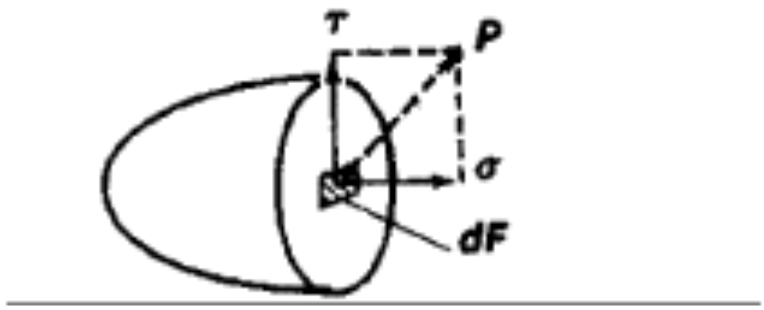
$$\text{Stress, } \sigma = \frac{\text{Force}}{\text{Cross-Sectional Area}} = \frac{F}{A_0}$$

Vector quantity of stress at the point M on elementary area ΔS: $\lim_{\Delta S}\left(\frac{\Delta P}{\Delta S}\right) = \rho$, it is a vector value. There are the components of stress:
1) normal stress σ
2) tangential stress τ

in which case $\rho^2 = \sigma^2 + \tau^2$

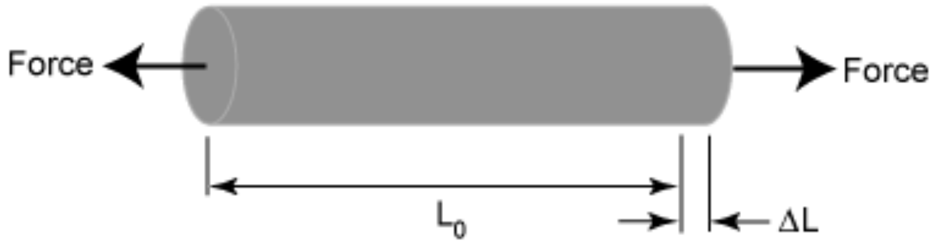
Stressed state at the point is characterized by aggregate of vectors for all parts of body.





Mechanical strain.

Strain is the reaction of mechanical stress. If we apply force to the object, it deforms. We can explain strain as ratio of the initial length and amount of deformation. It is the nondimensional quantity.
For example, primary value of length is L_0 , if bar is being stretched we have value of deformation (ΔL).
Distribution may or may not be homogeneous if nature of the pressure different.



There is mathematic definition of mechanical strain:

$$\text{Strain} = \frac{\text{Elongation}}{\text{Orininal Length}} = \frac{\Delta L}{L_0}$$

Hooke's law

A law stating that the stress applied to a material is proportional to the strain on that material. There is mathematic form of Hooke's law:

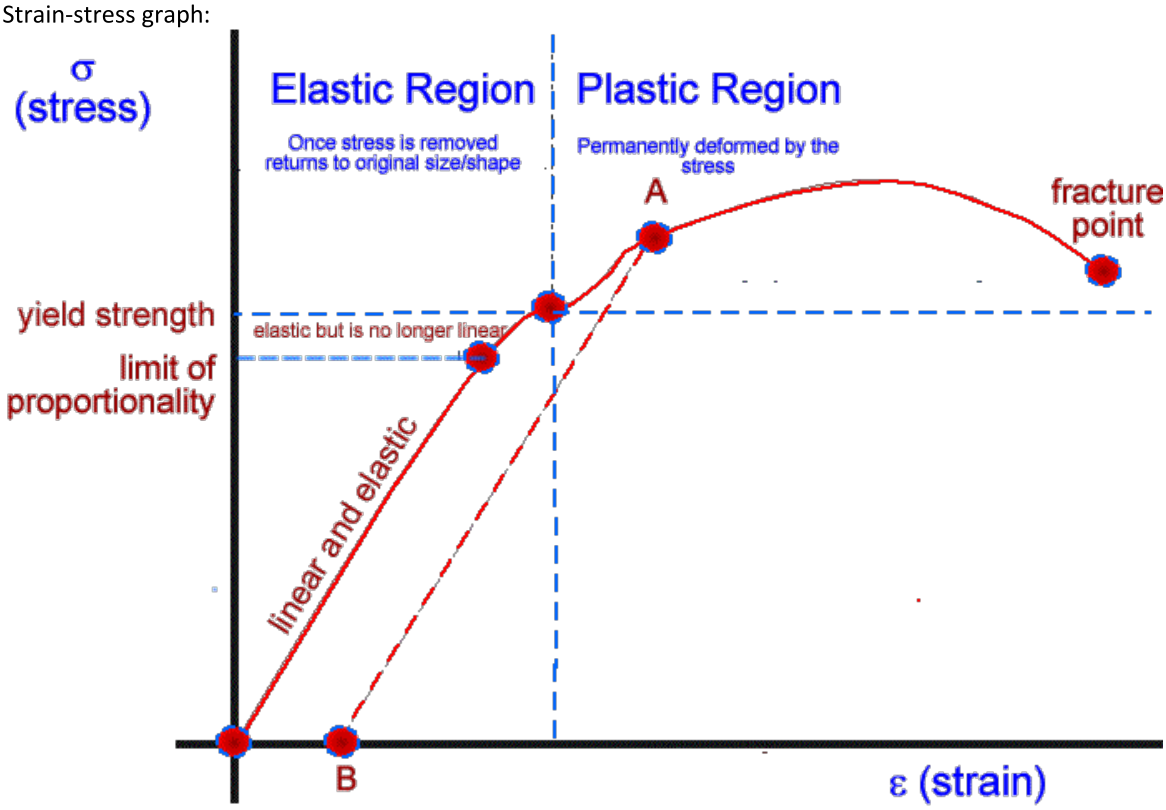
$$\sigma = \varepsilon E$$

where
strain is:

$$\varepsilon = \frac{\Delta l}{L}$$

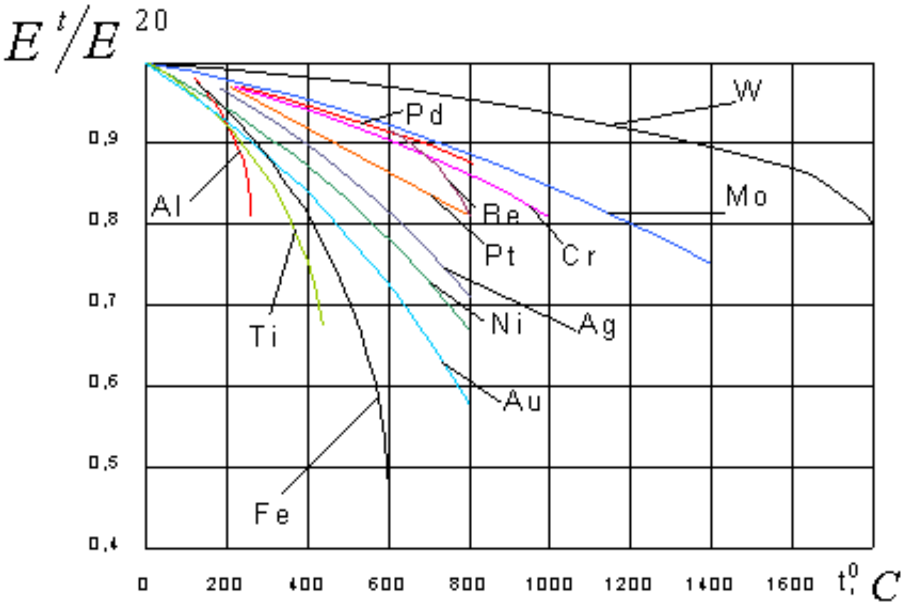
;

E - modulus of elasticity (also, called Young's modulus)
Strain-stress graph:

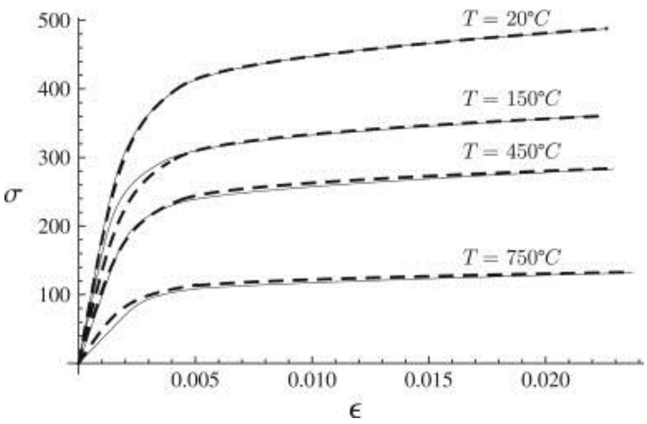


The *Young Modulus*, *E* is a material property that describes its stiffness and is therefore one of the most important properties in engineering design. [4]
E = stress / strain = (F / A) / (dL / L) ,
where
E = Young's modulus (N/m^2) $(lb/in^2$*, psi)*
If temperature increases Young's modulus decreases.
We can see this below.

There is plot for different metals:



Stress-stain graph if object was heated.
Thermal expansion is the tendency of matter to change in volume in response to a change in temperature.[3]
If temperature increases velocity of atoms, molecules increase. That's why average distance between atoms increases too. The *Young Modulus*, *E* is depend on temperature. We can see this below.



Bibliography:
1) http://www.ndt-ed.org/EducationResources/CommunityCollege/Materials/Mechanical/StressStrain.htm

2) http://encyclopedia2.thefreedictionary.com/Mechanical+Stress

3) 3 Paul A., Tipler; Gene Mosca (2008). *Physics for Scientists and Engineers, Volume 1* (6th ed.). New York, NY: Worth Publishers. pp. 666–670. ISBN 1-4292-0132-0

4) http://www.matter.org.uk/schools/content/youngmodulus/default.htm